# Behavioral Ecology of Narwhals in a Changing Arctic

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## LONG-TERM GOALS

Our primary goals are to understand baseline narwhal (*Monodon monoceros*) behavioral ecology in the pack ice of Baffin Bay. We will collect innovative data on the species' acoustic, movement, and diving ecology in the offshore pack ice of Baffin Bay over a 4 year long research program with three ecological focus areas (acoustic ecology, sea ice ecology, and foraging ecology). Our longitudinal and cross-population analyses will use a suite of ecological modeling approaches over a >2 decade period

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that encompass a period of sea ice decline and increased anthropogenic activities in West Greenland (1993-present).

## OBJECTIVES

Our objectives are to answer the following science questions:

1. Acoustic ecology: What are baseline characteristics of the acoustic repertoire of narwhals in the offshore Baffin Bay pack ice (depth-specific high frequency calls, echolocation clicks, and buzzes on the descent, bottom, and ascent of foraging dives)? What is the ecophysiological and communicative function of various click types of narwhals in this high-latitude offshore ice covered habitat? How might acoustic communication and foraging ecology be impacted by increasing anthropogenic activities in Baffin Bay (increasing shipping, future transit through the NW Passage, seismic exploration, increasing tourism)?

2. Sea ice habitat selection: How are narwhals' movements in Baffin Bay related to sea ice concentration, distance to the sea ice edge, location of glacial outlets, and the timing of sea ice break-up (as measured by the date when sea ice concentration drops below some threshold)? How have these relationships changed over the past two decades of sea ice loss? Are there population-level differences in sea ice habitat selection as measured by individual movement metrics (velocity, distance travelled, preferred locations, home ranges) and can those be related to changes in sea ice parameters?

3. Foraging ecology: Do the winter home ranges of narwhals overlap with high densities of Greenland halibut and are there habitat parameters that quantitatively describe the overlap of this predator and its prey? What is the potential predation impact on the offshore Greenland halibut stock as measured by bioenergetic models using updated narwhal abundance estimates, recent fisheries survey data, and knowledge of populations hot spots?

4. Predation: What are the spatial and temporal trends in the occurrence of killer whales in West Greenland? Given the loss of annual sea ice and purported increase in killer whales in the Canadian Arctic, do killer whale catch and observation data from West Greenland follow this trend and have narwhals been exposed to increasing risk of predation?

## APPROACH

*Pack ice field work*

We will design and build acoustic recording stations which will be set up at leads in pack ice within high-density offshore narwhal wintering grounds. These stations will record depth-specific high frequency calls, echolocation clicks, and buzzes on the descent, bottom portion, and ascent portion of narwhal foraging dives. We will take two approaches to collecting acoustic data from narwhals. First, we will deploy a 15Hz-480kHz hydrophone with pre-amplifier and recording using a National Instruments sound card with a sample rate of 500 kHz. Recent studies using wide-band acoustic sampling in the Northeast Atlantic have documented killer whales (*Orcinus orca*), the largest delphinid, produce whistles with the highest fundamental frequencies ever reported (Samarra et al. In Press). These ultrasonic whistles may also occur in medium sized odontocetes (i.e. narwhals) but has never been studied. The use of this first approach will ensure that the sampling scheme used to collect

baseline data on narwhal acoustics in the pack ice is not inherently constrained by *a priori* sampling decisions (where insufficient sampling frequency results in portions of whistles being missed). Second, we will deploy a vertical array of four calibrated lower-frequency hydrophones at a series of depths (300-900 m) that cover the range of narwhal foraging dives. This will allow us to collect depth-specific information on the production and frequency of regular echolocation clicks and lower level clicks (buzzes).

The first year of field work in the pack ice will be spring 2012 and the work in 2012 is intended to be a pilot study. The sampling in the second year of field work (2013) will be adjusted based on the results of 2012. All personnel and equipment will be deployed and retrieved from the ice using an Air Greenland helicopter (AS350). The helicopter will be used for spotting groups of narwhals and identifying ideal locations for deploying hydrophones.

During 2012 and 2013 we will instrument narwhals with satellite-linked time-depth recorders (SPLASH tags, Wildlife Computers) from leads in the ice. SPLASH tags collect information on animal location via the Argos system in addition to information on diving behavior. This tag will be developed for deployment on narwhals using a modified airgun (Air Rocket Transmitter System, ARTS) (by co-PIs Heide-Jørgensen and Villum Jensen). The tag design will be tested on narwhal summering grounds in 2011 (n=5 transmitters) with funds for the summer field season provided by the Greenland Institute of Natural Resources. Satellite tags will collect information on narwhal movements, diving and surface time in the pack ice and will coincide with the period of acoustic data collection.

*Analysis and habitat modeling*

We will use an extensive data analysis of over 18 years of satellite tracking and dive data (1993-2009) from five different subpopulations (Dietz and Heide-Jørgensen 1995, Dietz et al. 2001, Heide-Jørgensen et al. 2002, Heide-Jørgensen et al. 2003, Dietz et al. 2008) (Figure 4). The satellite tracking database includes tracking data from n=79 individual narwhals tagged in Melville Bay (West Greenland) (8 whales tagged in 1993 and 1994, and 8 whales tagged in 2006 and 2007), Somerset Island (Canada) (16 whales tagged in 2000 and 2001), Eclipse Sound (Canada) (11 whales tagged in 1997, 1998, and 1999), and Admiralty Inlet (Canada) (34 whales tagged in 2003, 2004, and 2005), and Uummannaq (West Greenland) (2 whales tagged in 2007 and 2008).

We will use the narwhal satellite tracking data to identify individual trajectories, focal areas, and population-level home ranges. We will examine speed, dispersal, and movements under different ice regimes and quantify fine scale winter habitat selection/sea ice characteristics within focal areas by extracting a suite of habitat variables and remotely-sensed data on sea ice conditions. Sea ice concentration data will be used to construct resource selection functions (RSFs), to compute long-term trends in sea ice parameters in specific regions of Baffin Bay identified as important to narwhals, and to compute sea ice parameters along the trajectories followed by narwhals. Satellite passive microwave data from SMMR and SSM/I (1979-present) (25-km pixel size) will be the primary data source for investigating ice trends. AMSR-E data will be used to compute specific parameters in the post-2002 period at a higher resolution (6.25 km pixel size). We will also use AMSR-derived daily sea ice velocity fields in Baffin Bay (supplied by Dr. Ron Kwok at the Jet Propulsion Laboratory) and SSM/I-derived sea ice velocity fields (from NSIDC in Boulder) to characterize the sea ice velocity and its variability. Finally, we will use information on the ice front location, discharge rates and advancement

or recession trends in glacial ice drainage sites along the coast of West Greenland (Moon and Joughin 2008) where narwhals migrate to quantify preference or avoidance of glacial ice habitat.

We will compile all available data on killer whale occurrence, dedicated and opportunistic sightings, and harvest records in West Greenland and Baffin Bay since 1970s and look at trends in the occurrence of narwhal predators, as well as spatial and temporal overlap based on the spatial models of area use. These records are kept by the Hunting Department of the Government of Greenland and for each catch record of killer whales details are recorded by hunters (submitted in catch reporting annually) and are available to our study through our collaboration with the Greenland Institute of Natural Resources.

## WORK COMPLETED

In September 2011, we purchased 60 barrels of jet-A helicopter fuel. We have set out fuel depots along the coast of West Greenland (in Niaqornat, Qaarsut, Upernavik) which will be utilized in March 2012 during the pack ice field work. Fuel must be set out in autumn before the sea ice forms and makes it impossible to reach areas by boat.

We have also been in the planning phase of the acoustic component. We have had a meeting with National Instruments in Denmark in April 2011 to discuss a data logging system for our vertical array, and have had discussions with several companies about hydrophones. We expect to make equipment purchases in the next 4-6 weeks.

## RESULTS

None.

## IMPACT/APPLICATIONS

**1. New baseline information on the ecology of narwhals in the pack ice.** This study will provide the first critical baseline data on acoustic foraging ecology of narwhals in an area rapidly being altered by increases in shipping, seismic exploration, and sea ice loss. We anticipate our results will be of broad interest to managers for predicting impacts of anthropogenic activities on this vulnerable species.

Potential future impact for Science and/or Systems Applications

**2. New techniques for ecological studies of whales using telemetry.** Our study develops technical and methodological advances for whale tagging in the Arctic. Design and deployment of satellite transmitters for whales will be refined based on field efforts during this project to improve attachment.

**3. New bioenergetic models for narwhals.** Our study will develops new bioenergetic models for narwhals which can be previously compared to that reported in Laidre et al. (2004). The bioenergetic models of narwhal predation pressure will be useful in determining to what extent narwhal predation in offshore Baffin Bay impacts halibut biomass and will be critical in the context of a developing offshore Arctic fishery, where managers must balance use of new resources while protecting key regions for top predators (i.e. fisheries exclusion areas).

## RELATED PROJECTS

None.

## PUBLICATIONS

None.